

Program of Research in Flight Dynamics
The George Washington University
at
NASA Langley Research Center

NASA Cooperative Agreement NCC1-326

Annual Status Report

December 1, 2002 – November 30, 2002

School of Engineering and Applied Science

The George Washington University

Washington, DC 20052

OVERVIEW

The program objectives are fully defined in the original proposal entitled "Program of Research in Flight Dynamics in GW at NASA Langley Research Center," which was originated March 20, 1975, and in the renewals of the research program from December 1, 2000 to November 30, 2001.

The program in its present form includes three major topics:

1. the improvement of existing methods and development of new methods for wind tunnel and flight test data analysis,
2. the application of these methods to wind tunnel and flight test data obtained from advanced airplanes,
3. the correlation of flight results with wind tunnel measurements, and theoretical predictions.

The Principal Investigator of the program is Dr. Vladislav Klein. Three Graduate Research Scholar Assistants (K. G. Mas, M. M. Eissa and N. M. Szyba) also participated in the program.

SPECIFIC DEVELOPMENTS

Specific developments in the program during the period December 1, 2002 through November 30, 2002, included:

1. Data analysis of highly swept delta wing aircraft from wind and water tunnel data.

For the analysis of wind and/or water tunnel forced-oscillatory data a new computer program was developed. This program selects a specified number of cycles, and computes the Fourier coefficients in the postulated model and their accuracies. In addition, the program provides measures for model adequacy in terms of the coefficient of determination and variance of measured data.

As an example, the variation of the rolling velocity in-phase and out-of-phase components with the angle of attack and reduced frequency is shown in figure 1. The data for the analysis were obtained from the measurements in the NASA LaRC 14 x 22 ft wind tunnel. From the analysis a linear model with an exponential indicial function was found to be adequate. The nondimensional time constant in the indicial function was around 16 for the angle of attack between 20° and 50° . A complete analysis of the data will be published as a NASA TM Report (in co-operation with Dr. P. C. Murphy).

During this period the data from the water tunnel experiment on the 2.5%-scale model have been collected. The data included:

- a) static data at different angles of attack, α , and sideslip angle, β ;
- b) oscillatory data with constant rate, simple harmonic and multiple harmonic inputs;
- c) rotary data from inclined-axis coning;
- d) flow visualization.

The static data were obtained from five different sets within the α – range of -10° to 80° and β – range of -10° to 10° . The increments in both variables were 1° . From the data the ensemble means were computed. In the next step the derivatives of aerodynamic coefficients, C_a , with respect to α and β will be computed and a model for $C_a(\alpha, \beta)$ determined.

The analysis of oscillatory data was initiated. Example time histories of input/output data using the multiple frequency input are shown in figure 2. Angle of attack, normal-coefficient free, C_N , and pitching-moment coefficients, C_m , at $\alpha = 30^\circ$ are presented. Figure 3 shows the estimates of the damping term, C_{N_q} , and the unsteady term, $C_{N_{\dot{\alpha}}}$, at various angles of attack and frequencies. The computed nondimensional time constant is plotted against α in figure 4. Similar results will be obtained for other

aerodynamic coefficients and compared with those obtained by using different estimation and experimental techniques. The results will be presented at the AIAA Atmospheric Flight Mechanics Conference, August 3-6, 2003 (in co-operation with Dr. P. C. Murphy).

There were contributions to the proposed AIAA Paper "Evaluation and Analysis of F-16XL Wind Tunnel Data from Dynamic Tests," by S. Kim, P. C. Murphy and V. Klein, and to the proposed NASA TM Report "Evaluation and Analysis of F-16XL Wind Tunnel Data from Static and Dynamic Tests," by S. Kim, P. C. Murphy and V. Klein.

2. Aerodynamic characteristics of the radio control aircraft from flight test.

The flight testing of the FASER (Free Flying Aircraft for Sub-Scale Experimental Research) was delayed due to technical and administrative problems. The beginning of flight testing is expected in Spring, 2003. In preparation of these tests the work on linking the joystick to the computer representing the FASER simulator was initiated.

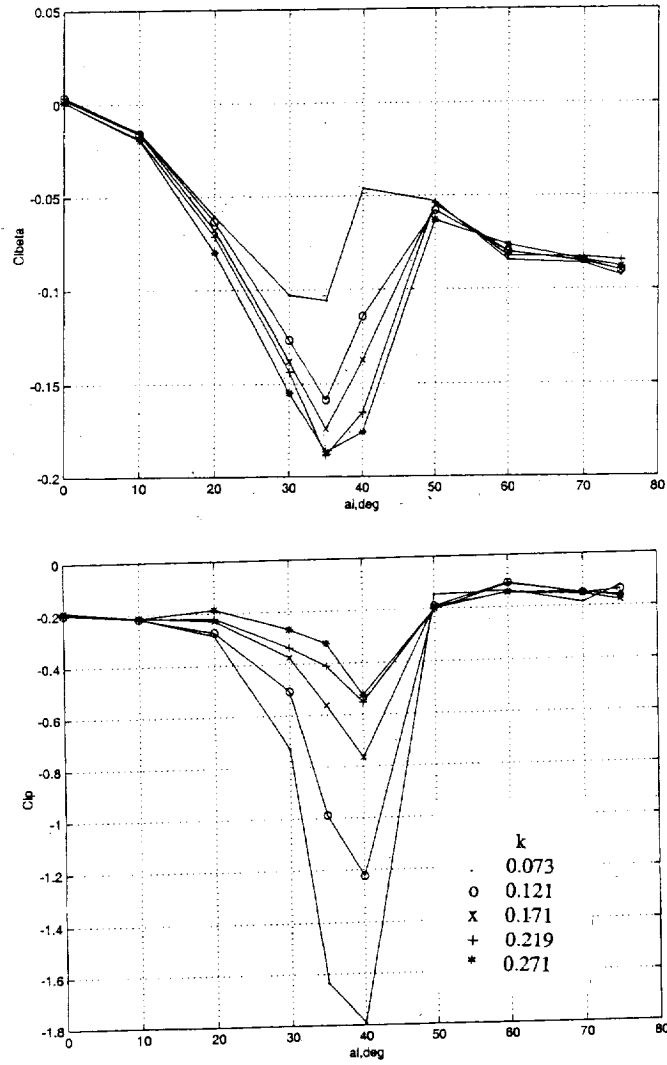


Figure 1. Variation of in-phase and out-of-phase components with angle of attack for different values of reduced frequency

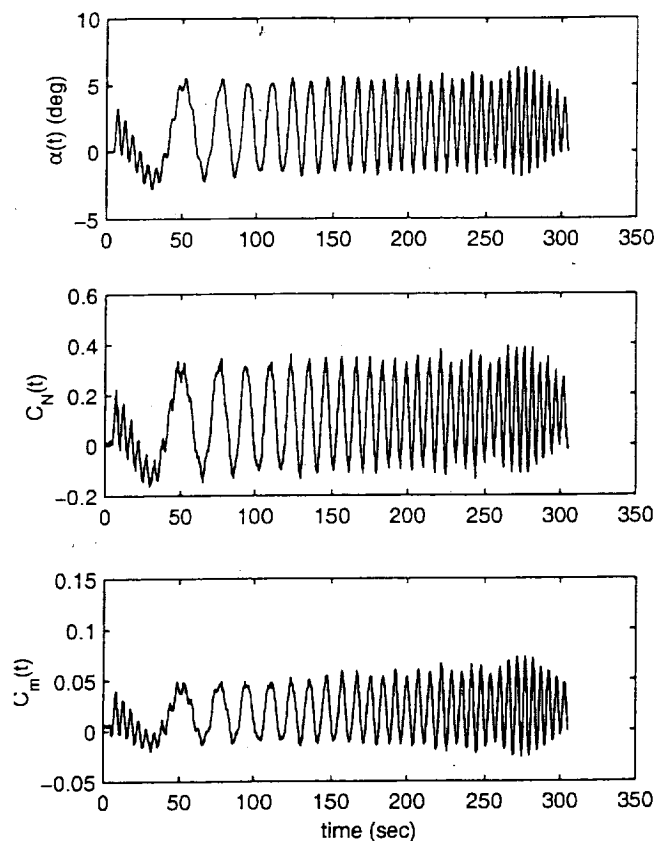


Figure 2. Time histories of angle of attack, lift, and pitch-moment coefficients for $\alpha_0=30$ degrees during wide-band input experiment in water tunnel.

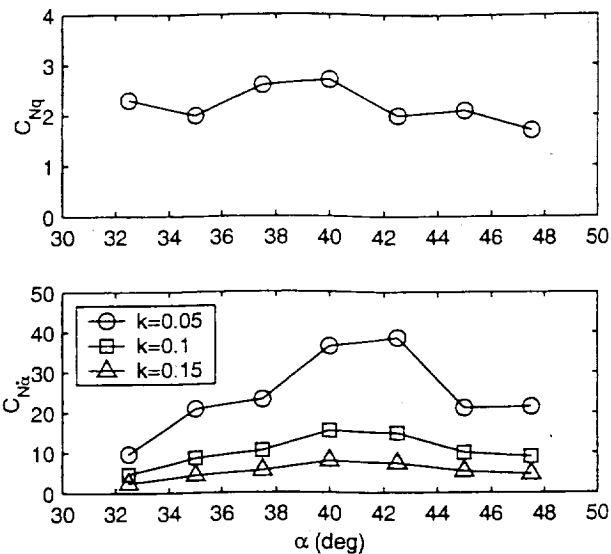


Figure 3. Variation of two damping terms with α and reduced frequency, k .

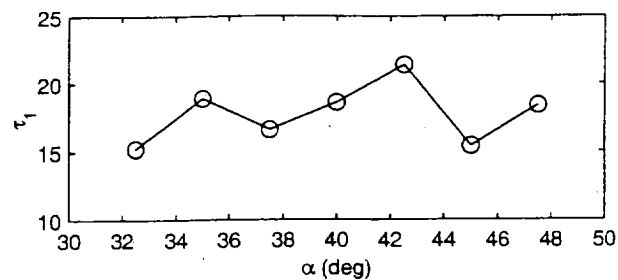


Figure 4. Variation of time constant with α (from analysis of Normal force coefficient).